REMARKS

In order to expedite the prosecution of the present application, the claims have been amended in order to more particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Specifically speaking, Claim 1 has been amended to state that the content of copper is 0.05% or less and that the content of iron is from 0.30 to 0.60%. Newly presented Claims 11-13 are also directed to preferred embodiments of the present invention. Support for the amendments to Claim 1 and newly presented Claims 11-13 can be found in Table 1 on page 12 of the present specification. No new matter has been added.

The current invention, as defined by Claim 1, is directed to an aluminum alloy piping material for automotive tubes having excellent corrosion resistance and formability and which is an annealed material of an aluminum alloy comprising, in mass %, 0.3 to 1.5% of manganese, 0.05% or less of copper, 0.10 to 0.20% of titanium, 0.30 to 0.60% of iron, and 0.50% or less of silicon with the balance being aluminum and unavoidable impurities. The aluminum alloy piping material has an average crystal grain size of 100 microns or less, and titanium-based compounds having a grain size of 10 microns or more do not exist as an aggregate of two or more serial compounds in a single crystal grain.

In the embodiment of the present invention described in Claim 6, the copper content is from 0.05 to 0.1% and the iron content is more than 0.20% but no more than 0.60%. Newly presented Claim 12 limits the copper content to 0.05 to 0.20% and the iron content to 0.45 to 0.60%.

As discussed previously, the aluminum alloy piping material of the instant invention is suitable for use as an automotive tube for connecting an automotive radiator and heater or for a tube connecting an evaporator, condenser and compressor. Conventional tubes used in connecting an automotive radiator and heater for an evaporator, condenser and compressor are typically expanded at the tube end by bulge

forming and have a rubber hose provided on the end thereof which is fastened by a metal band. Piping materials made of an aluminum-manganese alloy tend to have pitting or intergranular corrosion when used under extreme conditions. Moreover, when a rubber hose is provided on an end surface thereof, crevice corrosion tends to occur on the under side of the rubber hose on the outer surface of the piping material. Clad piping has been used to overcome this problem but this results in a significant increase in cost.

The aluminum alloy material of the present invention is formed under specific conditions in order for the material to have an average crystal grain size of 100 microns or less and titanium-based compounds having a grain size of 10 microns or more to not exist as an aggregate of two or more serial compounds in a single crystal grain. As discussed in the present specification, if the average grain size exceeds 100 microns, elongation and deformation of the piping material become uneven at the time of expansion work, which makes the material susceptible to developing an orange peel surface or cracks. Even if the average grain size is no greater than 100 microns, if titanium-based compounds having a grain size of 10 microns or more exist as an aggregate of two or more serial compounds in a single alloy crystal grain, stress concentrates during the expansion work and cracks occur from the titanium-based compound. In the present invention, during the manufacture of the inventive aluminum alloy piping, it is preferred that the reduction ratio of cold drawing is at least 30% and the total reduction ratio of hot extrusion and cold drawing be at least 99% and the temperature increase rate during annealing be 200°C per hour or more.

If the reduction ratio of cold working is less than 30%, the crystal grain size after annealing will become coarse and allow the titanium-based compounds to exist as an aggregate of two or more serial compounds in a single crystal grain. This makes the material prone to developing cracks at the time of expansion work. If the total reduction ratio of hot extrusion

and cold drawing is less than 99%, the titanium-based compounds formed during casting are not adequately dispersed and tend to exist at one location so that cracks develop at the time of expansion work.

Additionally, the smaller the temperature increase rate applied during annealing, the larger the crystal grain size after annealing which allows the titanium-based compounds to exist as an aggregate of two or more serial compounds in a single grain, which also makes the material prone to crack at the time of expansion work. It is respectfully submitted that the prior art cited by the Examiner does not disclose the presently claimed invention.

Claims 1-3 have been rejected under 35 USC 102(b) as being anticipated by JP 2002-180171A (JP '171). Claims 1-4 have been rejected under 35 USC 103(a) as being unpatentable over Sircar. Claim 6 has been rejected under 35 USC 103(a) as being unpatentable over JP '171. Claims 1-4 and 6-10 have been rejected under 35 USC 103(a) as being unpatentable over JP 04-285139A (JP '139). Applicants respectfully traverse these grounds of rejection and urge reconsideration in light of the following comments.

JP '171 discloses an aluminum alloy comprising, in mass %, 0.3 to 1.5% manganese, no more than 0.20% copper, 0.06 to 0.30% titanium, 0.01 to 0.20% iron, 0.01 to 0.20% silicon with the balance being aluminum and unavoidable impurities. Of the silicon-based compounds, iron-based compounds and manganese-based compounds present in the matrix of this aluminum alloy, the number of compounds having a diameter or 0.5 microns or more is 2×10^4 or less per square millimeter.

The presently claimed invention is distinguishable over JP '171 in that currently presented Claim 1 requires a minimum of 0.30% iron while the maximum iron content in JP '171 is 0.20%. Claim 6 also contains this limitation and Claim 7 requires that at least 0.45% iron be present. As such, JP '171 does not even present a showing of prima facie

obviousness under 35 USC 103(a) with respect to the currently claimed invention.

The Sircar reference shows an aluminum alloy composition consisting essentially of not more than about 0.03% copper, 0.1 to about 1.5% manganese, 0.03 to 0.35% titanium, magnesium in an amount up to about 1.0%, less than 0.01% nickel, between 0.06 and about 1.0% zinc, zirconium in an amount of up to about 0.3%, iron and silicon in amounts up to about 0.50%, up to 0.20% chromium with the balance being aluminum and inevitable impurities.

As pointed out previously, the manufacturing process of the alloy of Sircar is disclosed in Column 5, lines 13-20. There it is stated that an ingot having a thickness of 76.2 mm is hot-rolled to a thickness of 9.5 mm, which is a reduction of 87.9% and then cold worked. The reduction ratio of cold working and total reduction ratio is not disclosed in this reference. The thickness of the product automotive tubes is 1 mm. This means that there is a reduction from 76.2 mm to 1 mm, which is a reduction percentage of 98.7%. As pointed out previously, the piping material of the present invention cannot be obtained by such a process. In the present invention, it is required that the reduction ratio of cold drawing be 30% or more and that the total reduction ratio of hot extrusion and cold drawing be 99% or more. Additionally, the temperature increase ratio during annealing must be at least 200°C per hour.

If the reduction ratio of cold drawing is less than 30%, the crystal grain size after annealing will become coarse, which allows titanium-based compounds to exist as an aggregate of two or more serial compounds in a single crystal grain. This makes the material prone to develop cracks at the time of expansion work. If the total reduction ratio of hot extrusion and cold drawing is less than 99%, since the titanium-based compounds formed during casting are not adequately dispersed and tend to exist in one location, cracks develop at the time of expansion work.

It has also been discovered that the smaller the temperature increase rate applied during annealing, the larger the crystal grain size after annealing, which allows titanium-based compounds to exist as an aggregate of two or more serial compounds in a single crystal grain. This also makes the material subject to cracking at the time of expansion work.

As shown by the Examples and Comparative Examples contained in the present specification, it is critical that the claimed components be present in the alloy within the claimed ratios and for the alloys to be produced under specified working conditions in order to obtain the properties associated with the currently claimed invention. In Table 7, Specimens 50-53 fall within the scope of the present claims except that they were produced under conditions outside of the disclosure of the present invention. That is, Specimen 50 had a total reduction ratio of 98.1%, Specimen 51 had a reduction ratio of cold drawing of only 24.6%, Specimen 52 had a reduction ratio of cold drawing of 24.6% and a total reduction ratio of only 98.1% and Specimen 53 had a total reduction ratio of 98.1% and the temperature increase rate for annealing was only 100°C per hour. As shown in Table 8, these comparative specimens had inferior properties when compared with the alloys of the present invention.

Additionally, in Comparative Example 1 and Table 5 of the present specification, aluminum alloys are prepared having compositional ratios outside of the currently presented claims. As can be seen from Table 6, specimens outside of the scope of the present claims exhibited inferior properties as compared to those of the present invention. This is clearly unexpected in light of the generic disclosure of the Sircar reference and establishes the patentability of the presently claimed invention thereover.

JP '139 discloses an aluminum alloy pipe material containing 0.3 to 1.5% manganese, 0.10 to 0.60% copper, 0.06 to 0.35% titanium, 0.10 to 0.35% iron and 0.05 to 0.25% silicon or, furthermore, contains up to 0.4% manganese with

the balance being aluminum with inevitable impurities. As stated above for the Sircar reference, this reference does not show the criticality of the currently claimed compositional range or process conditions used for producing the alloys of the present invention. Given the showings of unobviousness in the specification of the presently claimed invention, it is respectfully submitted that the patentability of the presently claimed invention has been established over this reference.

The Examiner is respectfully requested to reconsider the present application and to pass it to issue.

Respectfully submitted,

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